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Research on Same-Gender Grouping in Eighth Grade Science Classrooms

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Abstract

This study examined two hypotheses related to same-gender grouping of eighth grade science classes in a public middle school setting. The hypotheses were (a) male and female students enrolled in same-gender science classes demonstrate more positive science academic achievement than their peers enrolled in mixed-gender classes, and (b) same-gender grouping of students has a positive effect on classroom climate. Participants were randomly assigned, and instruction did not vary for the same-gender and mixed-gender classes. The first experimental group was a class of all-male students (n = 20) taught by a male science teacher. The comparison group consisted of male students (n = 42) in coeducational classes taught by the same male teacher. The second experimental group was a class of all-female students (n = 23) taught by a female science teacher. This comparison group consisted of female students (n = 61) in coeducational classes taught by the same female teacher. Results of this study led to the conclusions that same-gender grouping did not produce significant differences in student science academic achievement and same-gender classes did not create a more positive classroom climate. For this middle school, policy recommendations include limiting same-gender grouping until further research indicates that this structure is effective in countering gender-stereotypes and improving achievement and attitudes toward science.

Research on Same-Gender Grouping in Eighth-Grade Science Classrooms

As a middle school principal, I observed a science class activity favored by teachers that occurred during the first week of school. Each student drew a picture of a scientist, and the results were intriguing. Most scientist pictures portrayed males, often with "nerdy" characteristics such as a pocket full of writing utensils or oversize eyeglasses. My practitioner's experience with young adolescents paralleled evidence in the literature to support findings that there are significant differences in science achievement and attitude toward science that are associated with gender (Brownlow, Rogers, & Jacobi, 2000; DeBacker & Nelson, 2000; Lee & Burkam, 1996; Tobin, 1996).

Males in the United States typically perform better than females on achievement measures in science and enroll in more advanced science classes; a higher percentage of males pursue careers in the field of science (Lee, Chen, & Smerdon, 1996; Manning, 1998; Marion & Coladarci, 1993). According to Weinburgh (2000), "Although females make up one half of the workforce, only about 15% of U.S. mathematicians, scientists and engineers are females" (p. 4).

In addition to concerns for female students in science, there is some indication that males are becoming the disadvantaged gender in schools, and that fewer males are interested in science (Bleuer & Walz, 2002; Sadker & Sadker, 1995; Weaver-Hightower, 2003). In a post-secondary study of degree attainment, the number of women and men who have graduated with doctoral degrees in the areas of science and engineering demonstrated a decline over a twenty-year period from 1970 to 1990. In 1970, 15.5% of males who completed undergraduate science degrees went on to pursue doctoral degrees in science and engineering, while in 1990, 8.7% of males completed doctoral degrees in science and engineering. The highest percentage of degree attainment for women was in 1970 at approximately 6.9% (Barber, 1995).

The purpose of this study was to determine whether single-gender grouping of eighth grade science classes leads to positive effects on student science academic achievement and science classroom climate. The research took place in a suburban middle school in the Midwest, and the study included two experimental groups. The first experimental group was an eighth grade science class of all-male students (n = 20) that was taught by a male science teacher. The comparison group consisted of the male students (n = 42) in the coeducational eighth grade science classes taught by the same male teacher. The second experimental group was an eighth grade science class of all-female students (n = 23) that was taught by a female science teacher. The comparison group for the female class consisted of the female students (n = 61) in the coeducational classes taught by the same female teacher (see Table 1).

Table 1
Research Study: Experimental and Comparison Groups of Male and Female Students in Eighth Grade Science Classes Taught by Male and Female Science Teachers

Teacher	Experimental Group	Comparison Group
A (Male)	Male students in eighth grade same-gender science class (n = 20)	Male students in two eighth grade co-educational science classes (n = 42)
B (Female)	Female students in eighth grade same-gender science class (n = 23)	Female students in three eighth grade co-educational science classes (n = 61)

This study examined two hypotheses related to same-gender grouping of eighth grade science classes in a public suburban middle school setting in the Midwest. The hypotheses were (a) male and female students enrolled in same-gender science classes demonstrate more positive science academic achievement than their peers enrolled in mixed-gender classes, and (b) same-gender grouping of students has a positive effect on classroom climate.

Rationale

The purpose of the study was to examine single-gender grouping for eighth grade science classes as a strategy for improving student science academic achievement and creating a more positive classroom climate. Research studies and standardized assessment results have demonstrated a need for educators to explore ways to close the gender gap in the area of science favoring males (e.g., Ferreira, 2001; Lee & Burkam, 1996; NAEP, 2005; Vasquez, Teferi, & Schicht, 2003). Prior research studies reported findings that same-gender grouping leads to higher academic achievement and a more positive classroom climate than coeducational groupings (e.g., Hamilton, 1985; Klebosits & Perrone, 1998; Norfleet James & Richards, 2003; Riordan, 1990). However, many other studies reported findings that results are negative or inconclusive when comparing achievement and environment in same-gender and coeducational settings (e.g., Datnow, Hubbard, & Woody, 2001; Ferney & Domingue, 2000; LePore & Warren, 1997; Viadero, 2002). A limited research base exists in the United States for same-gender education in public schools, due to *Title IX* restrictions on such programs. A provision in the *No Child Left Behind Act* (NCLB) of 2002 for single-sex programs in American public schools has contributed to reinterpretation of *Title IX*, and an increase in single-sex public school programs from the 12 that existed in May 2002 (NASBE) to 223 as of April 2006 (NASSPE).

Literature Review

Parochial and private institutions of learning have long provided an opportunity for students to attend same-gender schools in the United States. Public schools, however, have been subject to legislation that has until recent years restricted experimentation with single-sex public schools. The 1972 *Title IX* legislation prohibits discrimination on the basis of gender or race in any educational program receiving federal funds (Section 1681.a). In addition, many states have their own legislation related to equal rights that are open to interpretation by state courts.

Federal regulations that have prevented public school districts from creating single-sex schools or grouping students by gender for targeted classes have been in the process of revision and reinterpretation since the authorization of *NCLB* in 2002. *NCLB* included a provision for public school districts to apply for "Innovative Program" grant money available for more focused research and experimentation with single-gender education (OCR, 2002). The U.S. Department of Education conducted a review of *Title IX* regulations in 2003, and in 2004 the Secretary of Education proposed an amendment of the law to "expand flexibility for recipients that may be interested in providing single-sex schools or classes" (U.S. Dept. of Education, 04-5156). Mead (2003) stated that a U.S. Supreme Court decision would be required to resolve the questions of constitutionality of the same-gender public school issue. At present, over 200 public schools across the country have reformed structures to provide single-sex academies or single-sex classes (NASSPE).

Research related to single-gender schooling has led to diverse findings, and many studies have been conducted in private or parochial schools or single-gender schools outside the United States in countries such as Australia or Nigeria, where there are large numbers of public coeducational and same-gender schools to conduct research (e.g., Colley, Comber, & Hargreaves, 1994; Granleese & Joseph, 1993; Harker & Nash, 1997; LePore & Warren, 1997; Riordan, 1990; Stables, 1990). Some researchers reported findings that same-gender grouping leads to higher academic achievement and a more positive classroom climate than coeducational groupings (e.g., Lee & Bryk, 1986; Lee & Marks, 1990; Rowe, 1988). Others, such as those summarized in a 1998 report by the American Association of University Women (AAUW) find "there was insufficient evidence that single-sex education 'works or is better' than coeducation" (Viadero, 2002, p. 8).

According to a National Association of State Boards of Education (NASBE) policy update, in 2002 there were fewer than 12 single-sex schools in public education systems in the United States. The NASBE update also reported the perception that for boys, same-gender schools are effective in reducing dropout rates, truancy, and violence while improving academic achievement. The perceived benefits for female students include better academic performance, improved attitudes toward subjects which male students traditionally dominate, and the pursuit of a wider range of career paths.

While some research studies support these perceptions and other positive effects, the results are debatable due to the reasons stated in a NASBE update:

- Most studies of single-sex schools have been undertaken either in private schools or overseas. Student characteristics vary considerably between private and public schools and between American students and those of other countries; consequently, policymakers cannot assume that the positive outcomes associated with single-sex education documented by research would be replicated among diverse public school populations.
- Data suggest that parents and students who choose single-sex schools are more motivated and achievement-oriented than average. Therefore, the higher achievement documented in single-sex schools may be due to the nature of the students and families rather than the nature of the schools.
- Most single-sex schools have other attributes that correlate with higher academic achievement, such as a smaller student body, stronger emphasis on academics, and higher level of commitment to the school's mission. Consequently, the positive outcomes attributed to single-sex schools could be due to institutional factors other than the single-sex student body (NASBE, 2002, p.1).

Opponents to the concept of same-gender education, such as the American Civil Liberties Union and the National Organization for Women, have filed lawsuits aimed at ending public school experiments with same-gender grouping, citing problems with maintaining equal treatment in a segregated setting (Davis, 2002). The creation of single-sex schools in response to perceived inequities for male and female students equates to "separate but equal" educational practices. This concept hearkens back to the 1896 *Plessy v. Ferguson* case that established the "separate but equal" edict as related to racial segregation in schools. With the historical lessons learned from inequities existing in schools segregated by race, the question arises as to how segregating schools by gender works to promote equality and to discourage stereotypes.

Sadker and Sadker (1995) summarized research findings for males and females in coeducational school settings and in U.S. society. According to Sadker and Sadker, female students are disadvantaged in coeducational settings, including fewer opportunities to contribute vocally in classes, fewer leadership opportunities, and lower course enrollment and achievement in fields traditionally dominated by males. Male students have higher risk factors than females according to statistics related to accidents, suicides, and homicides. They are more likely to be labeled with learning or behavior problems in school, fail more classes, are retained at a higher rate, and are more likely to drop out of school. Sadker and Sadker also noted an achievement gap between white males and minority males, as well as lower levels of self-esteem for minority or low socio-economic students (pp. 197–217).

Science teachers at the middle school level have been encouraged to increase the use of student active participation in daily learning activities. The National Science Foundation sponsored a study that analyzed gender differences that favored boys in science achievement among eighth grade students (Lee & Burkam, 1996). The findings included an interaction effect between classroom laboratory experiences and female science achievement. Notably, only about 25% of the male and female eighth grade students surveyed reported having even one laboratory experience per week.

According to Manning (1998), "Young adolescents are forming gender identities and self-esteem during these years—another reason why middle schools need to provide gender-responsive learning environments and experiences" (p. 171). Early experiences contribute to gender identities, such as toys that are associated more frequently with males or females; dolls for the girls and a microscope or chemistry set for boys (Crawford, 1996). Ashby (2004) conducted a study of science careers in relationship to *Title IX* and found that "discrimination in the workplace or subtler discrimination about what types of career or job choices women can make" contributed to lower participation by women in male dominated fields (p. 23).

Bleuer and Walz (2002) reported that recent studies demonstrate a female advantage over male students. Weaver-Hightower (2003) analyzed trends in current research that focus on the male experience in schools. This "Boy Turn" in educational studies includes examination of academic and socio-behavioral factors. Much of this recent work was based on qualitative research, with less emphasis on test scores due to the fact that "complex factors of race, urbanity as opposed to rurality, and socioeconomic status make simple boy-versus-girl comparisons insufficient" (p. 485).

Another element of this analysis was the concept of "multiple masculinities." Weaver-Hightower (2003) stated, "Individuals and social groups create and adapt versions of masculinity for their own uses within their own cultural frames" (p. 480). The unlimited forms of masculinity were described as being in conflict with achievement of dominance, and that hegemonic groups of males oppress certain masculinities such as men of color, men in poverty, or homosexual men. Disaggregation of these diverse forms of masculinity led to nuances in research findings, rather than creating one "male" group of results.

Baker and Jacobs (1999) examined curriculum and pedagogy in science education through observation of same-gender seventh grade male and female science classes in an urban middle school. They found that separating students into same-gender classes was detrimental to the students, because the teachers did not address curricular and pedagogical issues related to science instruction. "The all boy classrooms were noisier and more hostile environments. … Teachers showed favoritism and tolerated more disciplinary infractions

from girls" (p. 7). The findings related to student achievement included an observation that, "the same topics and activities were taught to boys and girls despite the fact that some topics and activities worked better with one sex than the other" (p. 5).

Datnow, Hubbard, and Woody (2001) studied the socio-political context of one suburban, one rural, and four urban school districts across the state of California that opened single-gender academies for male and female students in 1998. This three-year case study examined single-sex public schooling, encompassing more than 300 interviews with educators, policymakers, and students, in addition to school and classroom observations. In California, state legislation required same-gender schools to operate on the same campus. Reports of sexual harassment in coeducational spaces was consistent with investigations of harassment among students in mixed-gender schools. Use of the same school facilities and teachers for the California programs created gender comparisons and stereotyping, as well as opportunities for student interactions that would not occur in self-contained, single-gender schools.

Other findings included that the single-gender classes eliminated certain classroom distractions from the opposite sex, particularly for the girls. Teachers and students reported that the single-gender setting provided opportunities to dialogue openly about issues particular to adolescent boys or girls in each community. Fighting among girls did not necessarily improve in single-gender schools, as some students reported that instead of fighting over boys they fought over issues of friendship and gossiping about each other. Many boys noted an increase in teasing and disruptive behavior, while finding the single-gender classroom to be a more productive work environment.

The literature related to same-gender schooling demonstrates the need for credible studies in U.S. public schools. Research in the field of single-sex education is timely due to *NCLB* encouraging this strategy as a means to improve student achievement. As public schools experiment with same-gender education, attention to research-supported theory and practice is of great importance to the creation of same-gender programs. Advocates for same-gender schooling state opinions that the setting enhances educational opportunity and frees students from gender stereotypes. Opponents to the same-gender education movement believe that "separate but equal" is discriminatory and unconstitutional.

Methodology

Research Questions

Specifically, this study addressed the following research questions: (1) Will same-gender grouping of eighth grade science classes produce statistically significant gains over mixed-gender grouping in the area of student science academic achievement as measured by classroom assessment and overall science class trimester grades? (2) Will the classroom climate in all-female and/or all-male groupings demonstrate significantly more positive findings when compared to coeducational groupings as measured by a repeated measures classroom climate survey administered to students each trimester, and qualitative classroom observations? The acceptable level of statistical significance was set at .05.

Site Selection

The middle grades school selected for this study was located in a suburban school district in the Midwest. The district was in a metropolitan area with enrollment of approximately 30,381 students and a student-teacher ratio of approximately 18:1. The district middle schools served nearly 5,000 students. The middle school chosen for the study had an enrollment of approximately 500 students from several different municipalities. Each of the communities within the middle school's attendance area had unique cultural and socio-economic diversities. The ethnic diversity of the student population was approximately 86% Caucasian, 4% Black, 8% Hispanic, and 2% Asian/Pacific Islander.

During the 2002–2003 school year, the middle school became a pilot program for a "departmentalized scheduling" concept. The new structure included the following changes: (a) dissipation of the small learning communities composed of "teams" of students and teachers, (b) discontinuation of the daily 45-minute interdisciplinary team planning period for teachers, (c) replacement of the advisory period with an

independent study hall, and (d) random assignment of students to classes instead of grouping students according to specific teams of teachers. While the school continued to be called a "middle school" in the community, the organizational changes were not in alignment with the philosophy and characteristics associated with middle schools. In the new scheduling concept, all teachers were assigned six 45-minute instructional class periods, one supervision period, and one personal planning period. The random assignment of students to core classes enabled male and female students to be scheduled into separate science classes for the duration of this study.

Sample

Approximately 250 eighth grade students were enrolled in the middle school. Each eighth grade student was randomly assigned into heterogeneous groups by a computer scheduling program into one class period of eighth grade science during the enrollment process in the Spring of 2002. One male and one female teacher taught science during the second period of the school day. Forty-three students were assigned to the two sections of second period science. These students formed two different science classes, one composed of twenty males and the other class composed of twenty-three females. The male teacher taught the male class, and the female teacher taught the female class. Parents and students returned signed letters of consent to participate in the study, and all participants opted to take part in the study.

Research Procedure

The two single-gender eighth grade science classes examined in this study met at the same time during the school day, approximately 9:30 until 10:15 a.m. The all-female class instructor was a female teacher who taught five additional sections of coeducational eighth grade science classes during the school day. The all-male class instructor was a male teacher who taught three additional sections of coeducational eighth grade science classes during the school day. Both teachers have more than fifteen years experience teaching eighth grade science at the targeted middle school. The male teacher and female teacher each had earned a Master's degree plus sixty additional graduate credit hours. The teachers operated independently to prepare lesson plans using the same science curricular objectives and instructional resources.

The single-gender classes were the experimental groups. These classes followed the same lesson plan and instructional methodology as the coeducational classes taught by each teacher that served as the comparison groups. A quantitative analysis of data collected was used to compare academic achievement and classroom climate perceptions of female students in the single-gender class compared to the female students in the coeducational classes taught by the female teacher, and to compare academic achievement and classroom climate perceptions of male students in the single-gender class compared to male students in the coeducational classes taught by the male teacher. In addition, the two science teachers were interviewed six times during the school year using a semi-structured protocol to prompt reflection on the similarities and differences between the same-gender and mixed-gender classes, and their observations and anecdotal information were recorded.

Students in the single-gender and the coeducational eighth grade science classes completed a classroom climate survey developed by the researcher in November 2002, in February 2003, and in May 2003. The survey utilized a Likert scale that included response options strongly disagree, disagree, agree, strongly agree, and not sure. Each survey took approximately 15 minutes to complete (see Appendix for survey information).

The male teacher and the female teacher did not develop different lesson plans for the same-gender and mixed-gender classes; eighth grade science students in the experimental and comparison groups participated in the same learning activities facilitated by each teacher. Science academic achievement was measured for both groups through a quantitative analysis using grades on science classroom assessments and overall science course grades for three trimester (twelve-week) grading periods. Classroom climate was measured through scripted observations conducted twice for each same-gender and mixed-gender science class (a total of eight, 45-minute observations) and through qualitative and quantitative analysis of a 20-question student survey administered at the end of each trimester grading period. Observations were conducted on the same day for each pairing of classes (i.e., same-gender male lesson observed on the same day as the mixed-gender class taught by the male teacher), in order to observe the same lesson plan with each group.

In the area of student achievement, classroom assessment grades and trimester science grades for the single-gender and coeducational eighth grade science classes were analyzed using Levene's Test for Equality of Variances Independent Samples *t*-test and descriptive statistics that reported the mean and standard deviation for the experimental and comparison groups. The entering science achievement levels of the students were analyzed using sixth grade Cognitive Abilities Test results and Iowa Test of Basic Skills science subtest results. Student participants were anonymous, in order to maintain student confidentiality.

Results

Quantitative Analysis

Data collected during the school year were entered into the data program SPSS and analyzed to determine statistical significance. A preliminary analysis of the means examined each measure related to student science academic achievement. The results of this analysis indicated that the means of the scores for females in the same-gender class were higher than the means of the scores for females in the mixed-gender classes for the six classroom assessments and for two of the three science class trimester grades, though not statistically significant at the .05 level (see Table 2). The raw data for the male students indicated that the means of the scores for males in the same-gender science class were higher than the means of the scores for males in the mixed-gender classes for classroom assessments one and two, and for the three science class trimester grades, though also not to the .05 level of statistical significance (see Table 2).

Table 2
Means of Classroom Assessment and Trimester Science Class Grades for Female and Male Students in Same-Gender and Mixed-Gender Classes

Science Academic Measure (Means)	Female Same-Gender	Female Mixed-Gender	Male Same-Gender	Male Mixed-Gender
Test 1	83.14 (out of 100)	79.49 (out of 100)	52.14 (out of 80)	42.90 (out of 80)
Test 2	74.87 (out of 100)	69.90 (out of 100)	72.19 (out of 100)	71.32 (out of 100)
Trimester 1 Science Grade	83.90 (out of 100)	80.73 (out of 100)	78.43 (out of 100)	73.32 (out of 100)
Test 3	51.45 (out of 79)	49.90 (out of 79)	56.55 (out of 105)	62.58 (out of 105)
Test 4	107.41 (out of 138)	102.07 (out of 138)	70.90 (out of 100)	78.63 (out of 100)
Trimester 2 Science Grade	79.20 (out of 100)	79.43 (out of 100)	73.77 (out of 100)	72.64 (out of 100)
Test 5	59.60 (out of 87)	57.60 (out of 87)	75.05 (out of 100)	83.84 (out of 100)
Test 6	70.00 (out of 100)	68.30 (out of 100)	77.15 (out of 100)	79.90 (out of 100)
Trimester 3 Science Grade	78.50 (out of 100)	78.30 (out of 100)	72.76 (out of 100)	69.61 (out of 100)

Random assignment of students to the experimental and comparison groups occurred prior to the start of the school year. In order to determine whether ability and performance level differences were a factor in the results of this research experiment, analyses of sixth grade standardized testing were conducted. Results demonstrated equity for the female groups and significant differences in the Cognitive Abilities Test (CAT)

Non-Verbal and Composite scores and the Iowa Test of Basic Skills (ITBS) Science sub-test score between the males in the mixed-gender classes and the males in the same-gender class, whose average scores were lower. The statistical analysis accounted for this difference in the science class academic measures, and the results again were not statistically significantly different between the male experimental and comparison groups.

Analysis of the data related to science academic achievement included tests of statistical significance. An F-Test of all academic data determined whether a valid assumption could be made that the variances were equal for a two-sample *t*-test. For female students, in most cases, the assumption was that the variances were equal. The only exceptions were the second classroom assessment and the third trimester science class grade. In both cases, the second *t*-test did not change the outcome of the female student results.

Due to the significant differences in the CAT and ITBS Science scores for males, the analysis of male scores began with converting the percentiles to normal curve equivalents (NCEs). To account for these differences, the results for this statistical analysis assumed a mean difference of 13.4. Knowing that the same-gender male group tested significantly lower prior to this study, an alternative hypothesis was that the difference of the means was less than 13.4 NCEs (a one-tailed test at alpha = .05). The male tests indicated that most of the unit test scores do not have means that are within 13.4 NCEs of each other. This indicates that scores other than tests, such as daily homework assignments, lab activities, or class projects, equalized the trimester grades.

The first hypothesis stated that students enrolled in same-gender science classes demonstrate more positive science academic achievement than their male and female peers enrolled in mixed-gender science classes. Using an alpha of .05 and a null hypothesis that assumes there is no difference in the means of the female mixed and same-gender groups and the means of the male mixed and same-gender groups, statistical analyses indicated that there is no evidence supporting a difference in average scores for any of the tests. Single-gender grouping as the one variable enacted to impact science achievement did not make a significant difference.

Quantitative measures for the second hypothesis, that same-gender grouping of students in eighth grade science has a positive effect on classroom climate, utilized repeated-measures survey data. Students in the single-gender and the coeducational eighth grade science classes completed a classroom climate survey developed by the researcher in November 2002, in February 2003, and in May 2003. The survey utilized a Likert scale that included response options strongly disagree, disagree, agree, strongly agree, and not sure (see Appendix for survey information). Questions on the survey were grouped according to theme, with multiple questions for each theme to strengthen reliability of the instrument.

For the purpose of statistical analysis, the Likert scale values were converted as follows: 4 (strongly agree) = 2; 3 (agree) = 1; 2 (disagree) = -1; 1 (strongly disagree) = -2; 0 (undecided) = 0. Paired samples *t*-tests for each question produced results for each of the trials separately as well as for the combined results of each question. In some cases, the p-values for the individual trials were not consistent with the values obtained with all the data combined. Since a data pooling process is determined to be much more reliable, the analysis produced p-values for the combined results for each question.

In addition to the *t*-tests to determine statistical significance for the questions, a repeated-measures two-way ANOVA for the male and female survey data determined any further differences between each of the trials. Any student who did not take the survey all three times was not included in this data analysis. Forty-six females in this study completed the survey all three times. Thirty-five males in this study completed the survey all three times.

In the two-way mixed ANOVA, there were two independent variables with one within-subjects factor and one between-subjects factor. The within-subjects factor was the repeated-measures factor (the classroom climate survey administered three times). In the between-subjects factor, subjects were divided into discrete subgroups, and each subject went into only one of those subgroups (same-gender or mixed-gender class). Two questions included in this analysis were 1) whether there was a significant difference in the three trials of the survey, and 2) whether the same-gender male or female results differed significantly from the male or female results in the mixed-gender classes.

Though several individual components from the 20 questions on the survey indicated statistical significance, reliability necessitated pooling of data for the questions and repeated-measure results for the same-gender and mixed-gender groups. The aggregate analysis of data (multiple questions within each theme and repeated measures for the survey) for this study did not indicate support for either hypothesis. Data led to the conclusions that solely changing a school structure to create same-gender grouping did not produce significant differences in student science academic achievement, and that same-gender classes did not create a more positive classroom climate for male or female students.

Qualitative Analysis

The qualitative data gathered in this study included interviews with the teachers, comments from students on written surveys, and classroom observations. The multiple data sources in this study contributed to validity and the development of thick description (Geertz, 1973) for making meaning of the experiences of the participants relative to the nature of science class grouping according to gender. Data coding and cross-case analysis were conducted according to grounded theory, an inductive process for studying a phenomena, which "is discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon" (Strauss & Corbin, 1990, p. 23). These data elucidated some of the social interactions and perceptions of the persons who participated in the study. Themes that occurred throughout the qualitative information led to conclusions and construction of meaning relative to the research questions.

Although the lesson plans and objectives were the same for classes according to teacher report and classroom observations, the female same-gender class appeared to function more informally. The female mixed-gender class was more structured and students were guided through expectations step-by-step, such as reading the directions for an activity out loud. The classroom observations demonstrated several differences between the interaction of the teacher and students in the same-gender and mixed-gender science classes. The female teacher engaged in more off-topic conversations with the female students in the same-gender class. The rapport with the students in her mixed-gender classes appeared more formal, with "Mr." or "Ms." with the students' last names used in place of first names. The teacher's body language appeared more closed in mixed-gender classes, such as arms crossed while moving among table groups to monitor students as they worked.

The female teacher felt that there was more of a bonding in the female same-gender science class. She stated, "We can have more fun and not be pulled off. When guys are in class the humor gets wild. We [same-gender] can think it's entertaining and then get back to business. We can do more crazy things." The female teacher offered a special opportunity to attend a before-school chemistry workshop at the high school to the girls in her same-gender class. She said that ten students went to the event with her and that with that class she felt she could do different things such as that event. The female teacher stated, "There is more bonding going on; I felt like I wanted to go with them—offer something more special."

The instructional activities in the male teacher's classes were similar to those observed in the female teacher's classes. In the same-gender male class observations, there were several incidents of peer intimidation and some inappropriate conversations of a sexual nature. The rapport among the same-gender male students appeared to be one of hierarchy, with newer students and more introverted students having little or no interaction with the other boys, and some boys exhibiting more power in the socialization of the classroom, demanding attention.

The male teacher observed that the boys in the same-gender science class, "sometimes say things—kind of boy things they wouldn't say. Sometimes I can say things to them as a male teacher to boys I would never say if there were girls." The male teacher said that the class had been a good experience, and he was hoping the students would do well in science. He thought that most of the students would say positive things about the same-gender experience, and suggested math or social studies might be another place to try same-gender classes.

As in the Datnow, Hubbard and Woody (2001) California study, this experiment did not provide professional development or direction connected to gender equity in science for the teachers involved in the research. In order to determine the effects of a change in school structure to create single-sex classes, the only variable modified was the division of male and female students into separate-gender classes for the second-period, eighth grade science classes taught by the male and female teachers. The conclusions reached for the study were that the structural reform of same-gender grouping did not produce significant differences in student science academic achievement, and that same-gender classes did not create a more positive classroom climate for male or female students.

Discussion

Equity in education lies at the heart of the debate over same-gender education. Shor and Freire (1987) wrote, "… through education, we can first understand power in society. We can throw light on the power relations made opaque by the dominant class. We can also prepare and participate in programs to change society" (pp. 31–32). The roles of educators and parents carry with them the power to affect the attitudes, values, and beliefs of young people. Often these influential individuals are unaware of the ideals that they pass on through their words and actions.

Lee, Marks, and Byrd (1994) conducted a study to explore the nature and prevalence of sexism in high-school classrooms, finding that "gender domination" occurred in many coeducational classrooms, particularly in science classes. The findings included a different kind of sexism in boys and girls' schools identified as "gender reinforcement," or sex-role stereotyping, especially in single-sex schools with a gender match between teachers and students. In boys' schools, most incidents of sexism occurred in English classes, while sexism in girls' schools was somewhat evenly distributed across subject areas.

Several examples of "gender reinforcement" transpired in the same-gender classes in this study. During a lesson on sunspots in the same-gender female class, students focused on the aesthetic elements of a graph, such as using colored pencils and mounting the completed graph on construction paper. The teacher made feminine-oriented comments such as, "This is pretty—it turned out nice," and "There are a lot that look nice," which appeared to reinforce the emphasis on creating an attractive graph. Other female-specific comments included addressing the group as "Girls," with comments such as, "OK girls, let's keep on task, some chatter is not on topic."

Toward the end of the class period the teacher announced that the completion of the questions was more important than the graph. Students began to rush and worked to share answers with one another to copy responses to the questions in order to complete the assignment on time. With regard to behavior, there was a female student who exhibited bullying-type behaviors, getting out of her seat on several occasions to put tape in a student's hair and on a student's arm, and to push a student's chair in to the table to squeeze her between the chair and table. The student's actions were relatively covert and not noticed by the teacher as the teacher monitored student progress around the room. At the end of the class period, the student began to grab another girl's shoulders and bump into her. The teacher told her to "grab a seat," and concluded the lesson by telling students that they needed to study.

Differences in behaviors observed with the same lesson in the mixed-gender class included a much greater task-orientation on the completion of the questions than on the graphing part of the project. Male and female students engaged in louder talking during the class period, and several male students were out of their seats during class. A male student was moved to the front of the room due to making noises and "keeping everybody else off-task." One off-task conversation at the beginning of class focused on a boy's stitches after he attracted the attention of the girls by asking them if they wanted to see his stitches (located in his mouth), and which another male student then asked to see. When a student got up to staple his paper the teacher told him to staple it gently, to which the student replied, "It doesn't work if you don't slam it." The teacher replied, "Try … we like our men to be gentle with their staplers."

These interactions typify the gender-stereotyping that occurs in classrooms, often without teachers and students being conscious of the gender-bias or discrimination that takes place. Based on the findings for this research study, there is support that modification of a school structure to create same-gender classes is not sufficient to address gender inequity in education. The data yielded results that suggest the teachers and students involved in the study continued to reinforce gender-stereotypes in the classroom. Recommendations for future studies would include addressing the gender-related "hidden curriculum" and the teachers,' students,' and parents' unexamined attitudes and beliefs toward male/female learning in the field of science. In addition, examination of science instruction that includes appropriate text materials, motivational strategies, and stimulating learning activities with regard to student achievement and attitude toward science would be valuable professional development for teachers.

Weaver-Hightower (2003) described a fallacy of bifurcation in the field of gender research that focuses on either the male or the female experience in education.

> Finding ways to create curriculum and pedagogy that suit many different students is partly a pragmatic concern, because boys and girls are most commonly schooled together … Educationalists have thus far been unable to envision gender in its relational interdependencies; instead, first it was girls, and now it is boys. What is needed, rather, is curriculum, pedagogy, structures, and research programs that understand and explore gender (male, female, and "other") in complexly interrelated ways and that avoid "girls then, boys now." How might we research and write about boys *and* girls within the same article or book? (pp. 489–490)

This study generated a conclusion that reform of school structures alone will not bring about lasting and meaningful change. Supportive structures are an important factor in facilitating the change process when combined with other elements. In the context of systems theory, school organizations are open systems that must consider the extent to which the environment and other people have an impact on the learning community (Sergiovanni & Starratt, 2002). School stakeholders may be uncomfortable questioning the underlying assumptions that conceptual frameworks related to gender in schools entail. Tobin (1996) stated that, "The factors that determine whether or not males and females engage in the same way with science are complex, because of the joint influences of the teacher, the students and the culture in which the curriculum is embedded" (p. 126).

The need for further credible studies related to single-sex grouping in American public schools appears throughout the literature related to same-gender schooling (PPSS, 2005). Without a preponderance of research results in support of single-sex classes or schools in U.S. public education, the question arises as to whether or not such changes in structure should be initiated without policies requiring justification or rationale for the decision. In a letter to the Department of Education, the American Association of University Women (AAUW) argued that since public schools are not required to submit plans for same-gender schools or classes to the Office of Civil Rights for review prior to implementation of these structural reforms, "How would a school ensure equality in education? In *Brown v. Board of Education,* the Supreme Court said 'separate but equal' is inherently unequal because segregation sets up real opportunities for discrimination and stereotyping whether it is intentional or not" (Rustad & Woods, 2004, p. 10).

Implications for current practices that permit formation of single-sex classes or schools in any public school setting include potential inequities caused by reinforcement of gender stereotypes or an absence of accountability for public schools choosing to implement same-gender programs. This study demonstrated evidence of such gender reinforcement and found that in the area of science, creating a same-gender learning environment without professional development for teachers to promote stimulating learning activities that counter gender-stereotypes proved to have no positive effects on student achievement and attitudes toward science. The federal agenda promotes public school engagement with single-sex education to improve student achievement, but a more comprehensive approach involves examination of the curriculum and pedagogy related to issues of gender equity prior to creating "separate but equal" settings.

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Appendix
Classroom Climate Survey Information

The questions in the climate survey were grouped for analysis according to theme. Questions 1, 7, 10, 13, and 15 relate to student's attitude toward science class achievement.

01. I am satisfied with my academic progress in science class this year.
07. During lab activities, some students dominate the group or take on more than their share of responsibilities.
10. I feel successful in science class this year.
13. I contribute positively to class discussions.
15. During lab activities, each student has an equal part in completing the requirements of the lab.

Questions 2, 6, 12, and 17 relate to the student's perceived relationship with the science teacher.

02. When I raise my hand to answer a question in science, there is a good chance the teacher will call on me.
06. I believe that the science teacher likes me.
12. Students are treated fairly by the teacher in science class.
17. I am overlooked by the teacher when I raise my hand to participate in science class.

Questions 5, 9, and 14 relate to the student's perception of peer relations in the science class.

05. I am scared to participate in science class because of some of the other students.
09. Some students in my science class pick on other classmates during class.
14. Students in science class help one another during instruction.

Questions 3, 11, 16, 19, and 20 relate to the student's perception of student behavior in the science class. Response options for the last two survey questions included 0–5%, 6–10%, 11–15%, 16–20%, and more than 20%.

03. Other students in the science class distract me during instruction.
11. Students in science class talk out before raising their hands and waiting for the teacher to call on them.
16. Students in science class act in a kind and respectful manner.
19. What percent of science class time is spent dealing with disruptive or inappropriate student behavior?
20. What percent of time in your other classes is spent dealing with disruptive or inappropriate student behavior?

Questions 4 and 8 relate to the student's perception of a safe class environment.

04. I feel comfortable asking questions in science class when I don't understand something.
08. I feel safe in science class.

Question 18 relates to the student's attitude toward the same-gender science class experience.

18. If I had the opportunity next year, I would choose to be in a same-gender science class. (all male or all female students)